Charles Darwin University

Final Examination

Family Name	
Given Name/s	
Student Number	
Teaching Period	Semester 2, 2018

STA101 – Statistics 1	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

- Exam has eight questions.
- Answer all questions of the exam.

Exam has 80 marks.

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
No additional printed material is permitted	1 x 20 Page Book Formula Sheet/s 1 Scrap paper

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1 (5 marks)

Table 1 gives the grades of a class in 2018.Construct a stem and leaf display for the given data.

Table 1

56	54	61	71	46	61	55	68
60	66	54	61	52	36	64	51

Question 2 (15 marks)

Table 2 gives the number of incorrect answers provided by children having different ages. Answer the following questions:

a) Draw a scatter diagram of the data. (5 marks)

b) What is the coefficient of linear correlation (r) of the data? (10 marks)

Table 2.

AGE (X)	2	4	5	6	6	7	9	9	10	12
Incorrect answers (Y)	12	13	9	7	12	8	6	6	7	5

Question 3 (19 marks)

Table 3 gives the number of people, who participated in number of mathematics lessons in daytime and evenings. If one person was randomly selected, answer the following questions:

a) Are "Day time" and "Evenings" events for the selected participant mutually exclusive? Explain. (2 marks)

b) Determine the probability of "preschool". (2 marks)

c) Determine the probability of "daytime". (2 marks)

d) Determine the probability of "not levels". (2marks)

e) Determine the probability of "preschool" or "evening". (2 marks)

f) Determine the probability of "preschool" and "daytime". (3 marks)

g) Determine the probability of "preschool" based on occurrence of "levels" category (P(daytime|levels)). (3 marks)

h) Determine the probability of an adult based on occurrence of "evenings" event (P(adult |event)). (3 marks)

Table 3.

Mathematics categories	Daytime	Evenings
Preschool	66	80
Levels	69	56
Adult	10	2
Total	145	138

Question 4 (8 marks)

For the probability function $P(x) = \frac{x^2+5}{50}$ (for x=1,2,3,4),

a) List the probability distribution (2 marks)

b) Sketch a histogram (2 marks)

c) Determine the mean (2 marks)

d) Determine the standard deviation. (2 marks)

Question 5 (6 marks)

The weights of ripe mangos are normally distributed with a standard deviation of 10 grams. Determine the mean weight of mangos if only 3% weight less than 200 grams.

Question 6 (9 marks)

A random sample of size 40 is selected from a population with the mean of 482 and standard deviation of 18. This sample of 40 has a mean, which belongs to a sampling distribution.

a) Determine the shape of the sampling distribution (1 marks)

b) Find the **mean** and **standard error** of the sampling distribution (2 marks)

c) Find the probability that the sample mean will be between 475 and 495? (2 marks)

d) Find the probability that the sample mean will have a value less than 478? (2 marks)

e) Find the probability that the sample mean will be within 5 units of the mean? (2 marks)

Question 7 (12 marks)

The average of completion time of assignments for the all first year students of the university is 2 hours and 50.1 minutes with standard deviation of 21.0 minutes. It is claimed that IT students require more hours to complete their assignments. In order to verify this statement, 12 IT students were randomly selected and completion time of their assignments is given in Table 4. Answer the following questions:

a) At the 0.05 level of significance, do data show sufficient evidence to conclude that the mean completion time of the assignment is longer than that of other students? (1 mark)

b) State the null and alternative hypotheses. (2 marks)

c) Specify the hypothesis test criteria. (2 marks)

d) Present the sample evidence. (2 marks)

e) Determine the probability distribution information. (3 marks)

f) Determine the results. (2 marks)

Table 4.

140	208	187	173	164	195	170	163	187	150	170	208

Question 8 (6 marks)

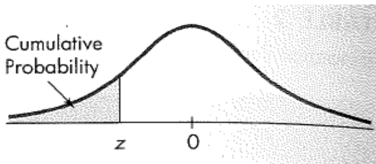
Use both the p-value and the classical approaches to hypothesis testing to reach a decision for the below situation. Assume α=0.05.

H_o: μ=128, H_a: μ≠128, n=15, t*=1.60

TABLE 3

Cumulative Areas of the Standard Normal Distribution

The entries in this table are the cumulative probabilities for the standard normal distribution z (that is, the normal distribution with mean 0 and standard deviation 1). The shaded area under the curve of the standard normal distribution represents the cumulative probability to the left of a z-value in the **left-hand tail**.

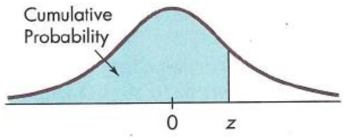


z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
−5.0	0.0000003									
−4.5	0.000003									
−4.0	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002	0.00002	0.00002	0.00002
−3.9	0.00005	0.00005	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00003	0.00003
−3.8	0.00007	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00005	0.00005	0.00005
−3.7	0.00011	0.00010	0.00010	0.00010	0.00009	0.00009	0.00008	0.00008	0.00008	0.00008
−3.6	0.0002	0.0002	0.0002	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.00011
−3.5	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
−3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
−3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
−3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
−3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
−3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
−2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
−2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
−2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
−2.6	0.0047	0.0045	0.0044	0.0043	0.0042	0.0040	0.0039	0.0038	0.0037	0.0036
−2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
−2.4	0.0082	0.0080	0.0078	0.0076	0.0073	0.0071	0.0070	0.0068	0.0066	0.0064
−2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
−2.2	0.0139	0.0136	0.0132	0.0129	0.0126	0.0122	0.0119	0.0116	0.0113	0.0110
−2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
−2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
−1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
−1.8	0.0359	0.0352	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
−1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
−1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
−1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
−1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
−1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
−1.2	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
−1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
−1.0	0.1587	0.1563	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
−0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
−0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
−0.7	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
−0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
−0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
−0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
−0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
−0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
−0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

TABLE 3

Cumulative Areas of the Standard Normal Distribution (*continued*)

The entries in this table are the cumulative probabilities for the standard normal distribution z (that is, the normal distribution with mean 0 and standard deviation 1). The shaded area under the curve of the standard normal distribution represents the cumulative probability to the left of a z-value in the **left-hand tail**.



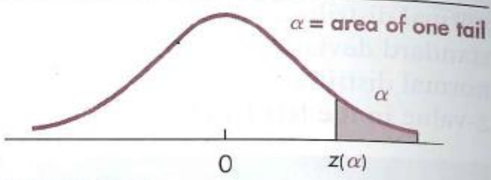
z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5754
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7258	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7518	0.7549
0.7	0.7580	0.7612	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7996	0.8023	0.8051	0.8079	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9430	0.9441
1.6	0.9452	0.9463	0.9474	0.9485	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9700	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9762	0.9767
2.0	0.9773	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9865	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9980	0.9980	0.9981
2.9	0.9981	0.9982	0.9983	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.99984	0.99985	0.99985	0.99986	0.99986	0.99987	0.99987	0.99988	0.99988	0.99989
3.7	0.99989	0.99990	0.99990	0.99990	0.99991	0.99991	0.99992	0.99992	0.99992	0.99992
3.8	0.99993	0.99993	0.99993	0.99994	0.99994	0.99994	0.99994	0.99995	0.99995	0.99995
3.9	0.99995	0.99995	0.99996	0.99996	0.99996	0.99996	0.99996	0.99996	0.99997	0.99997
4.0	0.99997	0.99997	0.99997	0.99997	0.99997	0.99997	0.99998	0.99998	0.99998	0.99998
4.5	0.999997									
5.0	0.9999997									

TABLE 4

Critical Values of Standard Normal Distribution

A ONE-TAILED SITUATIONS

The entries in this table are the critical values for z for which the area under the curve representing α is in the right-hand tail. Critical values for the left-hand tail are found by symmetry.

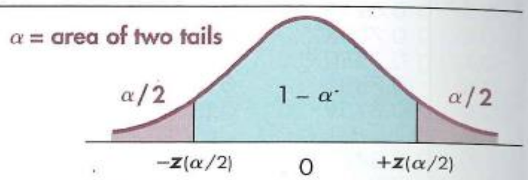


	Amount of α in one tail						
α	0.25	0.10	0.05	0.025	0.02	0.01	0.005
$z(\alpha)$	0.67	1.28	1.65	1.96	2.05	2.33	2.58

One-tailed example:
$\alpha = 0.05$
$z(\alpha) = z(0.05) = 1.65$

B TWO-TAILED SITUATIONS

The entries in this table are the critical values for z for which the area under the curve representing α is split equally between the two tails.



	Amount of α in two tails					
α	0.25	0.20	0.10	0.05	0.02	0.01
$z(\alpha/2)$	1.15	1.28	1.65	1.96	2.33	2.58
$1 - \alpha$	0.75	0.80	0.90	0.95	0.98	0.99
	Area in the "center"					

Two-tailed example:
$\alpha = 0.05$ or $1 - \alpha = 0.95$
$\alpha/2 = 0.025$
$z(\alpha/2) = z(0.025) = 1.96$

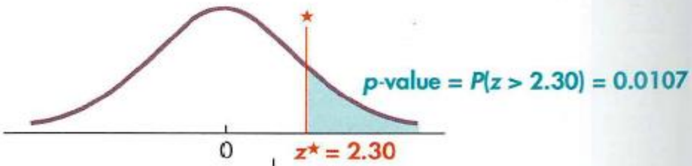
For specific details about using Table A to find critical values, see page 393.

For specific details about using Table B to find confidence coefficients, see pages 348, 350, 356; for critical values, see pages 393, 395–396.

TABLE 5

p-Values for Standard Normal Distribution

The entries in this table are the *p*-values related to the right-hand tail for the calculated $z\star$ for the standard normal distribution.



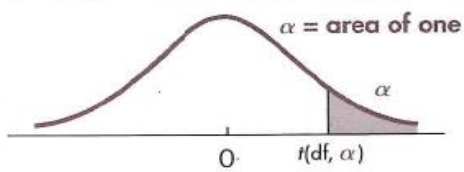
$z\star$	*p*-value	$z\star$	*p*-value	$z\star$	*p*-value	$z\star$	*p*-value	$z\star$	*p*-value
0.00	0.5000	0.80	0.2119	1.60	0.0548	2.40	0.0082	3.20	0.0007
0.05	0.4801	0.85	0.1977	1.65	0.0495	2.45	0.0071	3.25	0.0006
0.10	0.4602	0.90	0.1841	1.70	0.0446	2.50	0.0062	3.30	0.0005
0.15	0.4404	0.95	0.1711	1.75	0.0401	2.55	0.0054	3.35	0.0004
0.20	0.4207	1.00	0.1587	1.80	0.0359	2.60	0.0047	3.40	0.0003
0.25	0.4013	1.05	0.1469	1.85	0.0322	2.65	0.0040	3.45	0.0003
0.30	0.3821	1.10	0.1357	1.90	0.0287	2.70	0.0035	3.50	0.0002
0.35	0.3632	1.15	0.1251	1.95	0.0256	2.75	0.0030	3.55	0.0002
0.40	0.3446	1.20	0.1151	2.00	0.0228	2.80	0.0026	3.60	0.0002
0.45	0.3264	1.25	0.1056	2.05	0.0202	2.85	0.0022	3.65	0.0001
0.50	0.3085	1.30	0.0968	2.10	0.0179	2.90	0.0019	3.70	0.0001
0.55	0.2912	1.35	0.0885	2.15	0.0158	2.95	0.0016	3.75	0.0001
0.60	0.2743	1.40	0.0808	2.20	0.0139	3.00	0.0013	3.80	0.0001
0.65	0.2578	1.45	0.0735	2.25	0.0122	3.05	0.0011	3.85	0.0001
0.70	0.2420	1.50	0.0668	2.30	0.0107	3.10	0.0010	3.90	0+
0.75	0.2266	1.55	0.0606	2.35	0.0094	3.15	0.0008	3.95	0+

TABLE 6

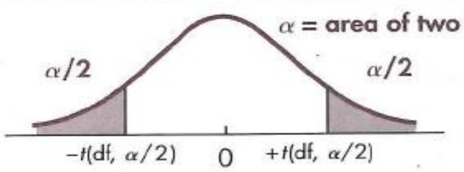
Critical Values of Student's t-Distribution

The entries in this table are the critical values of the Student's t-distribution, for which the area under the curve is: a) in the right-hand tail, or b) in two tails. See the illustrations at the bottom of the page.

	Area in One Tail: 0.25	0.10	0.05	0.025	0.01	0.005
df	**Area in Two Tails: 0.50**	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**
3	0.765	1.64	2.35	3.18	4.54	5.84
4	0.741	1.53	2.13	2.78	3.75	4.60
5	0.727	1.48	2.02	2.57	3.36	4.03
6	0.718	1.44	1.94	2.45	3.14	3.71
7	0.711	1.41	1.89	2.36	3.00	3.50
8	0.706	1.40	1.86	2.31	2.90	3.36
9	0.703	$\boxed{1.38}$	1.83	2.26	2.82	3.25
10	0.700	1.37	1.81	2.23	2.76	3.17
11	0.697	1.36	1.80	2.20	2.72	3.11
12	0.695	1.36	1.78	2.18	2.68	3.05
13	0.694	1.35	1.77	2.16	2.65	3.01
14	0.692	1.35	1.76	2.14	$\boxed{2.62}$	2.98
15	0.691	1.34	1.75	2.13	2.60	2.95
16	0.690	1.34	1.75	2.12	2.58	2.92
17	0.689	1.33	1.74	2.11	2.57	2.90
18	0.688	1.33	1.73	2.10	2.55	2.88
19	0.688	1.33	1.73	2.09	2.54	2.86
20	0.687	1.33	1.72	2.09	2.53	2.85
21	0.686	1.32	1.72	2.08	2.52	2.83
22	0.686	1.32	1.72	2.07	2.51	2.82
23	0.685	1.32	1.71	2.07	2.50	2.81
24	0.685	1.32	1.71	2.06	2.49	2.80
25	0.684	1.32	1.71	2.06	2.49	2.79
26	0.684	1.31	1.70	2.05	2.47	2.77
27	0.684	1.31	1.70	2.05	2.47	2.77
28	0.683	1.31	1.70	2.05	2.47	2.76
29	0.683	1.31	1.70	2.05	2.46	2.76
30	0.683	1.31	1.70	2.04	2.46	2.75
35	0.682	1.31	1.69	2.03	2.44	2.72
40	0.681	1.30	1.68	2.02	2.42	2.70
50	0.679	1.30	1.68	2.01	2.40	2.68
70	0.678	1.29	1.67	1.99	2.38	2.65
100	0.677	1.29	1.66	1.98	2.36	2.63
df > 100	0.675	1.28	1.65	1.96	2.33	2.58



One-tailed example:
df = 9 and $\alpha = 0.10$
$t(\text{df}, \alpha) = t(9, 0.10) = 1.38$

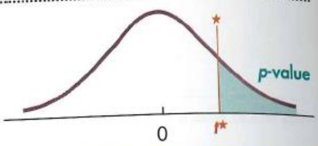


Two-tailed example:
df = 14, $\alpha = 0.02$, $1 - \alpha = 0.98$
$t(\text{df}, \alpha/2) = t(14, 0.01) = 2.62$

TABLE 7

Probability-Values for Student's t-distribution

The entries in this table are the p-values related to the right-hand tail for the calculated $t\star$ value for the t-distribution of df degrees of freedom.



	Degrees of Freedom														
$t\star$	3	4	5	6	7	8	10	12	15	18	21	25	29	35	df ≥ 45
0.0	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.1	0.463	0.463	0.462	0.462	0.462	0.461	0.461	0.461	0.461	0.461	0.461	0.461	0.461	0.460	0.460
0.2	0.427	0.426	0.425	0.424	0.424	0.423	0.423	0.422	0.422	0.422	0.422	0.422	0.421	0.421	0.421
0.3	0.392	0.390	0.388	0.387	0.386	0.386	0.385	0.385	0.384	0.384	0.384	0.383	0.383	0.383	0.383
0.4	0.358	0.355	0.353	0.352	0.351	0.350	0.349	0.348	0.347	0.347	0.347	0.346	0.346	0.346	0.346
0.5	0.326	0.322	0.319	0.317	0.316	0.315	0.314	0.313	0.312	0.312	0.311	0.311	0.310	0.310	0.310
0.6	0.295	0.290	0.287	0.285	0.284	0.283	0.281	0.280	0.279	0.278	0.277	0.277	0.277	0.276	0.276
0.7	0.267	0.261	0.258	0.255	0.253	0.252	0.250	0.249	0.247	0.246	0.246	0.245	0.245	0.244	0.244
0.8	0.241	0.234	0.230	0.227	0.225	0.223	0.221	0.220	0.218	0.217	0.216	0.216	0.215	0.215	0.214
0.9	0.217	0.210	0.205	0.201	0.199	0.197	0.195	0.193	0.191	0.190	0.189	0.188	0.188	0.187	0.186
1.0	0.196	0.187	0.182	0.178	0.175	0.173	0.170	0.169	0.167	0.165	0.164	0.163	0.163	0.162	0.161
1.1	0.176	0.167	0.161	0.157	0.154	0.152	0.149	0.146	0.144	0.143	0.142	0.141	0.140	0.139	0.139
1.2	0.158	0.148	0.142	0.138	0.135	0.132	0.129	0.127	0.124	0.123	0.122	0.121	0.120	0.119	0.118
1.3	0.142	0.132	0.125	0.121	0.117	0.115	0.111	0.109	0.107	0.105	0.104	0.103	0.102	0.101	0.100
1.4	0.128	0.117	0.110	0.106	0.102	0.100	0.096	0.093	0.091	0.089	0.088	0.087	0.086	0.085	0.084
1.5	0.115	0.104	0.097	0.092	0.089	0.086	0.082	0.080	0.077	0.075	0.074	0.073	0.072	0.071	0.070
1.6	0.104	0.092	0.085	0.080	0.077	0.074	0.070	0.068	0.065	0.064	0.062	0.061	0.060	0.059	0.058
1.7	0.094	0.082	0.075	0.070	0.066	0.064	0.060	0.057	0.055	0.053	0.052	0.051	0.050	0.049	0.048
1.8	0.085	0.073	0.066	0.061	0.057	0.055	0.051	0.049	0.046	0.044	0.043	0.042	0.041	0.040	0.039
1.9	0.077	0.065	0.058	0.053	0.050	0.047	0.043	0.041	0.038	0.037	0.036	0.035	0.034	0.033	0.032
2.0	0.070	0.058	0.051	0.046	0.043	0.040	0.037	0.034	0.032	0.030	0.029	0.028	0.027	0.027	0.026
2.1	0.063	0.052	0.045	0.040	0.037	0.034	0.031	0.029	0.027	0.025	0.024	0.023	0.022	0.022	0.021
2.2	0.058	0.046	0.040	0.035	0.032	0.029	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.017	0.016
2.3	0.052	0.041	0.035	0.031	0.027	0.025	0.022	0.020	0.018	0.017	0.016	0.015	0.014	0.014	0.013
2.4	0.048	0.037	0.031	0.027	0.024	0.022	0.019	0.017	0.015	0.014	0.013	0.012	0.012	0.011	0.010
2.5	0.044	0.033	0.027	0.023	0.020	0.018	0.016	0.014	0.012	0.011	0.010	0.010	0.009	0.009	0.008
2.6	0.040	0.030	0.024	0.020	0.018	0.016	0.013	0.012	0.010	0.009	0.008	0.008	0.007	0.007	0.006
2.7	0.037	0.027	0.021	0.018	0.015	0.014	0.011	0.010	0.008	0.007	0.007	0.006	0.006	0.005	0.005
2.8	0.034	0.024	0.019	0.016	0.013	0.012	0.009	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004
2.9	0.031	0.022	0.017	0.014	0.011	0.010	0.008	0.007	0.005	0.005	0.004	0.004	0.004	0.003	0.003
3.0	0.029	0.020	0.015	0.012	0.010	0.009	0.007	0.006	0.004	0.004	0.003	0.003	0.003	0.002	0.002
3.1	0.027	0.018	0.013	0.011	0.009	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002
3.2	0.025	0.016	0.012	0.009	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.002	0.002	0.001	0.001
3.3	0.023	0.015	0.011	0.008	0.007	0.005	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
3.4	0.021	0.014	0.010	0.007	0.006	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
3.5	0.020	0.012	0.009	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
3.6	0.018	0.011	0.008	0.006	0.004	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0+	0+
3.7	0.017	0.010	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0+	0+	0+
3.8	0.016	0.010	0.006	0.004	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0+	0+	0+	0+
3.9	0.015	0.009	0.006	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0+	0+	0+	0+	0+
4.0	0.014	0.008	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0+	0+	0+	0+	0+	0+

Formula Card for Johnson & Kuby, ELEMENTARY STATISTICS, Eleventh Edition

Sample mean:

$$\bar{x} = \frac{\sum x}{n} \quad (2.1)$$

Depth of sample median:

$d(\tilde{x}) = (n + 1)/2$ **(2.2)**

Range: $H - L$ **(2.4)**

Sample variance:

$$s^2 = \frac{\sum (x - \bar{x})^2}{n - 1} \quad (2.5)$$

or

$$s^2 = \frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n - 1} \quad (2.9)$$

Sample standard deviation:

$s = \sqrt{s^2}$ **(2.6)**

Chebyshev's theorem: at least $1 - (1/k^2)$ **(p. 99)**

Sum of squares of x:

$SS(x) = \Sigma x^2 - ((\Sigma x)^2/n)$ **(2.8)**

Sum of squares of y:

$SS(y) = \Sigma y^2 - ((\Sigma y)^2/n)$ **(3.3)**

Sum of squares of xy:

$SS(xy) = \Sigma xy - ((\Sigma x \cdot \Sigma y)/n)$ **(3.4)**

Pearson's correlation coefficient:

$r = SS(xy)/\sqrt{SS(x) \cdot SS(y)}$ **(3.2)**

Equation for line of best fit: $\hat{y} = b_o + b_1 x$ **(p. 146)**

Slope for line of best fit: $b_1 = SS(xy)/SS(x)$ **(3.6)**

y-intercept for line of best fit:

$b_0 = [\Sigma y - (b_1 \cdot \Sigma x)]/n$ **(3.7)**

Empirical (observed) probability:

$P'(A) = n(A)/n$ **(4.1)**

Theoretical probability for equally likely sample space:

$P(A) = n(A)/n(S)$ **(4.2)**

Complement rule:

$P(\text{not } A) = P(\bar{A}) = 1 - P(A)$ **(4.3)**

General addition rule:

$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$ **(4.4)**

General multiplication rule:

$P(A \text{ and } B) = P(A) \cdot P(B \mid A)$ **(4.5)**

Special addition rule for mutually exclusive events:

$P(A \text{ or } B \text{ or } \ldots \text{ or } E) = P(A) + P(B) + \cdots + P(E)$ **(4.6)**

Special multiplication rule for independent events:

$P(A \text{ and } B \text{ and } \ldots \text{ and } E) = P(A) \cdot P(B) \cdot \cdots \cdot P(E)$ **(4.7)**

Mean of discrete random variable:

$\mu = \Sigma[xP(x)]$ **(5.1)**

Variance of discrete random variable:

$\sigma^2 = \Sigma[x^2 P(x)] - \{\Sigma[xP(x)]\}^2$ **(5.3a)**

Standard deviation of discrete random variable:

$\sigma = \sqrt{\sigma^2}$ **(5.4)**

Factorial: $n! = (n)(n-1)(n-2) \cdot \cdots \cdot 2 \cdot 1$ **(p. 248)**

Binomial coefficient:

$$\binom{n}{x} = \frac{n!}{x!(n - x)!} \quad (5.6)$$

Binomial probability function:

$$P(x) = \binom{n}{x} \cdot p^x \cdot q^{n-x},\ x = 0, 1, 2, \ldots, n \quad (5.5)$$

Mean of binomial random variable: $\mu = np$ **(5.7)**

Standard deviation, binomial random variable:

$\sigma = \sqrt{npq}$ **(5.8)**

Standard score: $z = (x - \mu)/\sigma$ **(6.3)**

Standard score for $\bar{x}$: $z = \dfrac{\bar{x} - \mu}{\sigma/\sqrt{n}}$ **(7.2)**

Confidence interval for mean, μ (σ known):

$\bar{x} \pm z(\alpha/2) \cdot (\sigma/\sqrt{n})$ **(8.1)**

Sample size for $1 - \alpha$ confidence estimate for μ:

$n = [z(\alpha/2) \cdot \sigma/E]^2$ **(8.3)**

Calculated test statistic for H_o: $\mu = \mu_0$ (σ known):

$z\bigstar = (\bar{x} - \mu_0)/(\sigma/\sqrt{n})$ **(8.4)**

Confidence interval estimate for mean, μ (σ unknown):

$\bar{x} \pm t(\text{df}, \alpha/2) \cdot (s/\sqrt{n})$ with df $= n - 1$ **(9.1)**

Calculated test statistic for H_o: $\mu = \mu_0$ (σ unknown):

$$t\bigstar = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} \quad \text{with df} = n - 1 \quad (9.2)$$

Confidence interval estimate for proportion, p:

$p' \pm z(\alpha/2) \cdot \sqrt{(p'q')/n},\quad p' = x/n$ **(9.6)**

Calculated test statistic for H_o: $p = p_0$:

$z\bigstar = (p' - p_0)/\sqrt{(p_0 q_0/n)},\quad p' = x/n$ **(9.9)**

Calculated test statistic for H_o: $\sigma^2 = \sigma_0^2$ or $\sigma = \sigma_0$:

$\chi^2\bigstar = (n - 1)s^2/\sigma_0^2,\quad \text{df} = n - 1$ **(9.10)**

Mean difference between two dependentsamples:

Paired difference: $d = x_1 - x_2$ **(10.1)**

Confidence interval for mean difference, μ_d:

$\bar{d} \pm t(\text{df}, \alpha/2) \cdot s_d/\sqrt{n}$ with df$= n - 1$ **(10.2)**

Sample mean of paired differences:

$\bar{d} = \Sigma d/n$ **(10.3)**

Sample standard deviation of paired differences:

$$s_d = \sqrt{\frac{\sum d^2 - \frac{(\sum d)^2}{n}}{n-1}} \quad (10.4)$$

Calculated test statistic for H_o: $\mu_d = \mu_0$:

$t\bigstar = (\bar{d} - \mu_0)/(s_d/\sqrt{n}),\quad \text{df} = n - 1$ **(10.5)**

Difference between means of two independent samples:

Degrees of freedom:

df = smaller of $(n_1 - 1)$ or $(n_2 - 1)$ **(p. 496)**

Confidence interval estimate for $\mu_1 - \mu_2$:

$(\bar{x}_1 - \bar{x}_2) \pm t(\text{df}, \alpha/2)\sqrt{(s_1^2/n_1) + (s_2^2/n_2)}$ **(10.8)**

Calculated test statistic for H_o: $\mu_1 - \mu_2 = (\mu_1 - \mu_2)_0$:

$t\bigstar = [(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)_0]/\sqrt{(s_1^2/n_1) + (s_2^2/n_2)}$ **(10.9)**

Difference between proportions of two independent samples:

Confidence interval for $p_1 - p_2$:

$$(p'_1 - p'_2) \pm z(\alpha/2) \cdot \sqrt{\frac{p'_1 q'_1}{n_1} + \frac{p'_2 q'_2}{n_2}} \quad (10.11)$$

Pooled observed probability:

$p'_p = (x_1 + x_2)/(n_1 + n_2)$ **(10.13)**

$q'_p = 1 - p_p'$ **(10.14)**

Calculated test statistic for H_o: $p_1 - p_2 = 0$:

$$z\bigstar = \frac{p'_1 - p'_2}{\sqrt{(p'_p)(q'_p)\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right]}} \quad (10.15)$$

Ratio of variances between two independent samples:

Calculated test statistic for H_o: $\sigma_1^2/\sigma_2^2 = 1$:

$F\bigstar = s_1^2/s_2^2$ **(10.16)**

Calculated test statistic for enumerative data:

$\chi^2\bigstar = \Sigma[(O - E)^2/E]$ **(11.1)**

Multinomial experiment:

Degrees of freedom: df $= k - 1$ **(11.2)**

Expected frequency: $E = n \cdot p$ **(11.3)**

Test for independence or Test of homogeneity:

Degrees of freedom:

df $= (r - 1) \cdot (c - 1)$ **(11.4)**

Expected value: $E = (R \cdot C)/n$ **(11.5)**

Mathematical model:

$x_{c,k} = \mu + F_c + \epsilon_{k(c)}$ **(12.13)**

Total sum of squares:

$$\text{SS(total)} = \sum(x^2) - \frac{(\sum x)^2}{n} \quad (12.2)$$

Sum of squares due to factor:

$$\left[\left(\frac{C_1^2}{k_1}\right) + \left(\frac{C_2^2}{k_2}\right) + \left(\frac{C_3^2}{k_3}\right) + \cdots\right] - \left[\frac{(\sum x)^2}{\text{n}}\right] \quad (12.3)$$

Sum of squares due to error:

$\text{SS(error)} = \sum(x^2) - [(C_1^2/k_1) + (C_2^2/k_2) + (C_3^2/k_3) + \cdots]$ **(12.4)**

Degrees of freedom for total:

df(total) $= n - 1$ **(12.6)**

Degrees of freedom for factor:

df(factor) $= c - 1$ **(12.5)**

Degrees of freedom for error:

df(error) $= n - c$ **(12.7)**

Mean square for factor:

MS(factor) = SS(factor)/df(factor) **(12.10)**

Mean square for error:

MS(error) = SS(error)/df(error) **(12.11)**

Calculated test statistic for H_o: Mean value is same at all levels:

$F\bigstar$ = MS(factor)/MS(error) **(12.12)**

Covariance of x and y:

$\text{covar}(x, y) = \Sigma[(x - \bar{x})(y - \bar{y})]/(n - 1)$ **(13.1)**

Pearson's correlation coefficient:

$r = \text{covar}(x, y)/(s_x \cdot s_y)$ **(13.2)**

or

$r = \text{SS}(xy)/\sqrt{\text{SS}(x) \cdot \text{SS}(y)}$ **(3.2)** or **(13.3)**

Experimental error: $e = y - \hat{y}$ **(13.5)**

Estimated variance of error: $s_e^2 = \sum(y - \hat{y})^2/(n - 2)$ **(13.6)**

or

$$s_e^2 = \frac{(\sum y^2) - (b_0)(\sum y) - (b_1)(\sum xy)}{n - 2} \quad (13.8)$$

Standard deviation about the line of best fit:

$s_e = \sqrt{s_e^2}$ **(13.9)**

Estimate for variance of slope:

$$s_{b_1}^2 = \frac{s_e^2}{\text{SS}(x)} = \frac{s_e^2}{\sum x^2 - [(\sum x)^2/n]} \quad (13.12)$$

Confidence interval for β_1:

$b_1 \pm t(\text{df}, \alpha/2) \cdot s_{b1}$ **(13.14)**

Calculated test statistic for H_o: $\beta_1 = 0$:

$t\bigstar = (b_1 - \beta_1)/s_{b1}$ with df $= n - 2$ **(13.15)**

Confidence interval for mean value of y at x_0:

$$\hat{y} \pm t(n - 2, \alpha/2) \cdot s_e \cdot \sqrt{\frac{1}{n} + \frac{(x_0 - \bar{x})^2}{\text{SS}(x)}} \quad (13.17)$$

Prediction interval for y at x_0:

$$\hat{y} \pm t(n - 2, \alpha/2) \cdot s_e \cdot \sqrt{1 + \frac{1}{n} + \frac{(x_0 - \bar{x})^2}{\text{SS}(x)}} \quad (13.16)$$

Mann–Whitney U test:

$U_a = n_a \cdot n_b + [(n_b) \cdot (n_b + 1)/2] - R_b$ **(14.3)**

$U_b = n_a \cdot n_b + [(n_a) \cdot (n_a + 1)/2] - R_a$ **(14.4)**

Spearman's rank correlation coefficient:

$$r_s = 1 - \left[\frac{6\sum d^2}{n(n^2 - 1)}\right] \quad (14.11)$$